STRATEGIC LOCATION OF CONSERVATION PRACTICES RELATED TO COW-CALF PRODUCTION IN THE SOUTHERN PIEDMONT*

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ABSTRACT

Conservation practices have often been located without the use of geospatial data to help site practices for improved resource conservation. On a watershed scale, geospatial information can be used to identify water supplies and recreational areas that are least buffered from sources of contamination. Implementing conservation practices near these strategic locations could provide a more rapid means of increasing the ability of the watershed to support its designated uses. In grazing systems, rotation can prevent concentration of animals in one location. However, cow-calf pairs are difficult to move in the first few weeks after calving and producers often concentrate animals prior to calving to simplify animal care. Such practices may pose environmental threats to water quality by concentrating nutrients and exposing soil to erosion because of treading damage. Geospatial data can be used to identify pastures best suited for extended grazing and to select sites for conservation practices.

1.0 INTRODUCTION

Conservation practices have often been located by visual inspection of the landscape and funded by government organizations based upon the willingness of producer cooperators to implement a practice. On both a farm and watershed basis geospatial data can be used in the decision making process to maximize the returns in resource conservation. In the Southern Piedmont, many watersheds contain mixtures of confined animal production (poultry and swine) and extensive pasture-based beef production. On a watershed basis, geospatial information can be used to identify areas that pose the greatest threat to public water supplies and recreational waters. Implementing conservation practices at these locations could provide a more rapid means of improving water quality and increase the ability of the watershed to support all of its designated uses. Beef cow-calf production presents some unique challenges. Planned animal movements can prevent concentrating animals in a limited area for extended periods. This will minimize the concentration of nutrients and feces but cow-calf pairs are difficult to move in the first few weeks after calving. In addition, producers often concentrate animals just prior to calving to simplify observation. Land application of waste from confined animal operations is also often associated with areas used for grazing beef production. Practices associated with both activities may pose environmental hazards by concentrating nutrients, exposing soil to erosion, and creating a potential for runoff of fecal bacterial. Problems are exacerbated in those portions of a watershed where large quantities of feed are imported for confined animal production and there is limited land area available for manure distribution. Detailed information on the surface

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hydrology can suggest placement of pastures that are the most highly buffered locations for manure applications and for extended pasturing of cows with young calves. This information may also be used to locate and prioritize the installation of heavy use areas, buffer strips, riparian exclusion zones, and wildlife plantings to provide maximum positive environmental impacts.

The clustering of agricultural practices within a watershed, coupled with growing urban land use, makes water quality-related issues, and potential urban-agricultural conflicts, geospatial in nature. In this paper, data collected by the Georgia Environmental Protection Division (GA EPD) and from a Georgia Power Company water quality survey (Georgia Power, Personal communication) were used to identify practices impacting water quality in the Upper Oconee Watershed in the Middle Piedmont of Georgia (Figure 1). The focus of the paper will be on two agriculturally impacted areas. The first is the headwaters of the North Oconee, Middle Oconee, and Mulberry Rivers in which a high concentration of poultry production is located, and at the southern tip of which is located a major regional city (Athens). The second area is just west of Lake Oconee where a concentration of dairy production is located. The analysis suggests that geospatial data is useful for identifying areas of potentially high impact arising from agricultural and urban sources and to design possible amelioration strategies.

2.0 EXAMPLE OF AN IMPACTED WATERSHED

The Upper Oconee Watershed (HUC 03070101) in the Southern Piedmont USA covers approximately 7580 km^2 (Figure 1) and includes over 4,000 km of continuously flowing streams (EPAa, 1997). The human population of the watershed was estimated to be 269,000 in 1990 and is now likely to be over 290,000. Total withdrawals of water were 4,973 million $l\ d^{-1}$ in 1990 and, of that total, 98% of the withdrawals were surface water (EPAa, 1997). Agriculture accounts for <1% of the water withdrawn from the watershed but the potential agricultural impact on surface water is large with many confined animal production systems (primarily poultry) and extensive grazing lands. The current increase in urban land use makes this an important time to find effective means of reducing negative agricultural impacts on water quality to minimize agricultural and urban conflicts. The headwaters of the North Oconee, Middle Oconee, and Mulberry Rivers are in the northern portion of the watershed. The North Oconee flows through the mid-Piedmont to a major regional city (Athens). South of Athens, the North Oconee and Middle Oconee Rivers merge and flow through predominantly agricultural watersheds to Lake Oconee and then to Lake Sinclair. Lake Oconee is a Georgia Power reservoir and provides hydroelectric power, real estate development, and recreation for a large region. People from all sectors of the economy are concerned about water-related issues such as recreation, tourism, safety of the water supply as related to human health, and the effects of water quality on fishing, real estate values, and wildlife habitat. Animal-based agricultural provides the largest agricultural income and many jobs in the Upper Oconee Watershed. Animal production systems for poultry and dairy use large quantities of feeds that are imported into the watershed and, consequently, use manure disposal strategies that could lead to nutrient enrichment and degradation of watersheds. These operations are not randomly distributed throughout the watershed but are clustered. The manure produced by the confined animal operations is often land applied as a source of fertilizer for pastures grazed by beef cattle. Data collected by the GA EPD was obtained from the EPA STORET system (EPA, 1997b) for 1996 and from Georgia Power Company from a water quality survey in 1995 and 1996 (Georgia Power, Personal Communication). This manuscript will focus on two agriculturally impacted areas. First, the headwaters of the North Oconee, Middle Oconee, and Mulberry Rivers in which a high concentration of poultry production is located, and secondly, just west of Lake Oconee where a concentration of dairy production is located.

2.1 HEADWATERS AREA OF NORTH OCONEE, MIDDLE OCONEE, AND MULBERRY RIVERS

This area is comprised of approximately 100,000 ha in the northern portions of the Upper Oconee Watershed (NRCS, Personal Communication). The area cleared for agricultural is estimated to be 20,000 ha. The principal agricultural enterprises include beef, poultry, and timber production. There are approximately 550 poultry operations in the area producing 64 million broilers per year and managing 2 million layers. More than 33,000 beef cattle are grazed in this part of the watershed. These poultry and beef operations produce enough N in manure each year to apply 457 kg N agricultural ha^{-1} yr^{-1}. Data representing the 1996 calendar year collected by the GA EPD (EPA, 1997) were obtained to study surface waters likely to be impacted by agricultural production in this portion of the watershed. The data reported include turbidity (Hach units), P and N as mg l^{-1}, and fecal coliform bacteria estimated by presence and absence in serial dilutions to predict the most probable number of microbes (mpn $100ml^{-1}$). From the available data, eight sites were selected. Three sites are located just downstream from the impacted area (Figure 1, indicated by circles). They are North Oconee (Maysville), Middle Oconee (Arcade), and the Mulberry River. Impact further downstream in the watershed was assessed with the following four sample sites; North Oconee (Nicholson), North Oconee (Athens), Middle Oconee (Athens), and the Oconee River just above Lake Oconee. For comparison, samples from the Apalachee were included to represent a portion of the watershed with less impact from agriculture and urban development.

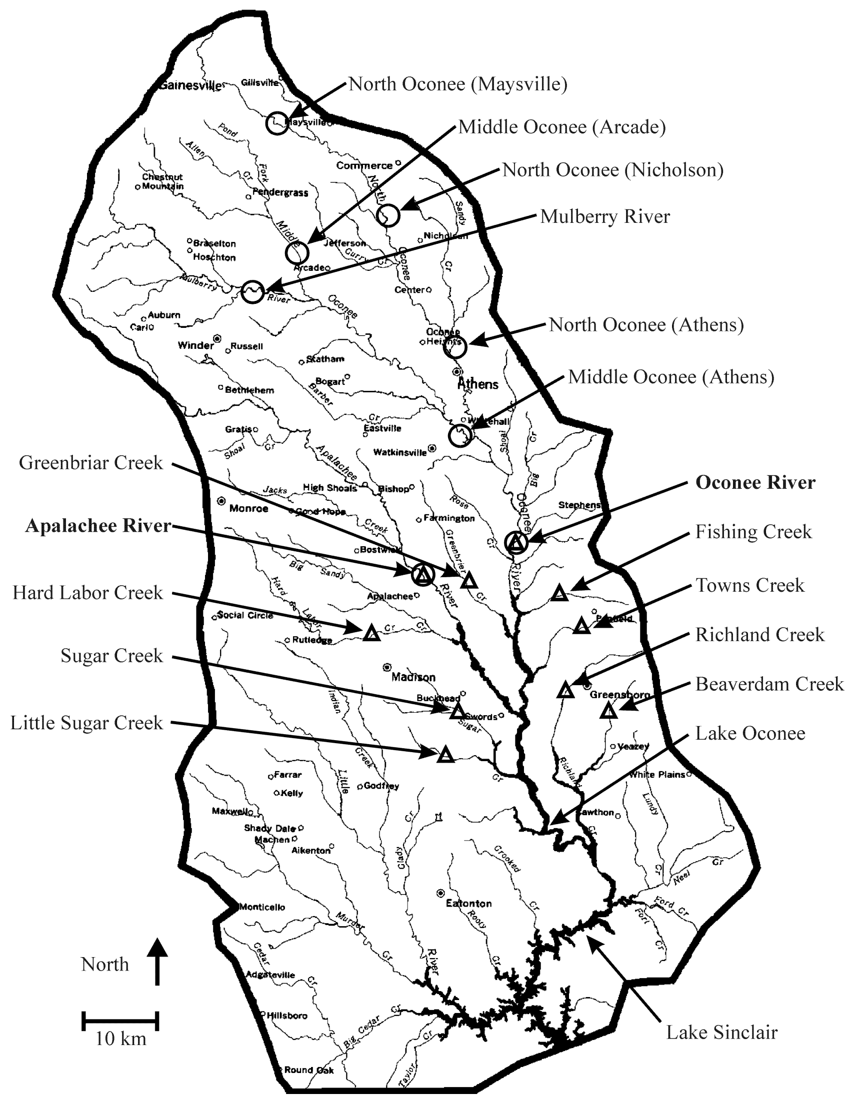

Figure 1. Diagram of Upper Oconee Watershed, GA with selected sampling sites from GA Environmental Protection Division (○) and Georgia Power Company (Δ) databases.

2.2 WEST OF LAKE OCONEE

This area is located in the central portion of the Upper Oconee Watershed to the west of Lake Oconee and is comprised of approximately 83,000 ha drained by Hard Labor, Sugar, and Little Sugar Creeks (Figure 1). Total area cleared for agriculture is estimated to be 26,000 ha. The principal agricultural enterprises include dairy, beef, poultry, and timber production. There are approximately 30 dairies and 30 poultry operations in the area. More than 21,000 beef cattle are grazed in this portion of the watershed. These operations produce enough N in waste each year to apply approximately 200 kg agricultural ha^{-1} yr^{-1} (NRCS, Personal Communication). Water quality data were made available by Georgia Power Company based upon sampling on a two-week interval from February 1995 through April 1996. The data reported include turbidity in Hach units, P and N as mg l^{-1}, and fecal coliform bacteria estimated by presence and absence in serial dilutions to predict the most probable number of microbes (mpn $100ml^{-1}$). A total of 10 sites (indicated by triangles in Figure 1) were summarized. Hard Labor, Sugar, and Little Sugar sampling sites represent the area previously described. The Apalachee River again represents a site with lower agricultural and urban impact. For comparison the following sites located around Lake Oconee are included; Greenbriar Creek, the Oconee River, Fishing Creek, Towns Creek, Richland Creek, and Beaverdam Creek.

3.0 WATER QUALITY DATA IN AN IMPACTED WATERSHED

3.1 HEADWATERS AREA OF NORTH OCONEE, MIDDLE OCONEE, AND MULBERRY RIVERS

The Maysville site on the North Oconee, the Arcade site on the Middle Oconee, and the Mulberry River site have levels of P and N that are higher than samples collected further downstream even though the rivers flow through beef production areas (Table 1). For example, median P and N concentrations in the North Oconee and Middle Oconee rivers at Athens are lower than sites on the North Oconee, Middle Oconee, and Mulberry Rivers nearer the headwaters area. Numbers of fecal coliform bacteria are also higher at the sites nearest the poultry production in the headwaters area but local urban and agricultural sources can also provide large numbers further into the watershed. The increase in numbers of fecal coliform between Nicholson and Athens deserves further study. Reduced application of poultry litter away from the headwaters area make the watershed partly effective in improving water quality by reducing P, N, and fecal coliform bacteria. Beef production away from the poultry production area makes less use of land applied poultry litter for pasture fertilization.

Table 1. Median estimates of water quality at 8 sites in the Upper Oconee Watershed, Georgia sampled once a month (n=12) in 1996 (Data from EPA STORET).

	Turbidity	P	N	FC
	Hach	mg l^{-1}	mg l^{-1}	mpn $100ml^{-1}$*
North Oconee (Maysville)	20	0.06	0.72	538
North Oconee (Nicholson)	24	0.05	0.57	280
North Oconee (Athens)	23	0.05	0.53	410
Middle Oconee (Arcade)	22	0.04	0.82	670
Middle Oconee (Athens)	20	0.04	0.79	370
Mulberry River (Winder)	24	0.06	0.80	745
Oconee River	19	0.09	1.00	395
Apalachee River	11	0.03	0.67	330

* Most probable number by presence and absence in serial dilutions.

A pronounced difference in the P and N load occurs between the two sample sites just above Athens and the site located on the Oconee River south of Athens. Median P doubles from 0.05 mg l^{-1} in the North Oconee near Athens and 0.04 mg l^{-1} in the Middle Oconee near Athens to 0.09 mg l^{-1} in the Oconee River just above Lake Oconee. Nitrogen increases from 0.53 and 0.79 mg l^{-1} near Athens to 1.00 mg l^{-1} near Lake Oconee. Both of the Athens sample sites are upstream from the wastewater treatment plant and this effect must be attributed to urban impact. Athens withdraws water from the Upper Oconee and discharges waste into the Middle Oconee near the confluence of the two rivers.

3.2 WEST OF LAKE OCONEE

Sample sites were obtained that represent the major rivers and creeks that drain into Lake Oconee (Table 2). Even though the time interval and dates differed for these estimates of turbidity, P, and N the Oconee and Apalachee Rivers are similar to those estimated by the Georgia EPD. Fecal coliform numbers are not strictly comparable because differing serial dilution procedures resulted in different saturation levels for the two assays.

Table 2. Median estimates of water quality at 10 rivers and creeks sampled approximately every two weeks in 1995 (n=20 to 29) near Lake Oconee, Georgia (Data from Georgia Power).

	Flow	Turbidity	P	N	FC
	l/s	Hach	mg/l	mg/l	mpn/100ml*
Oconee River	39474	24	0.09	0.88	397
Apalachee River	8070	18	0.04	0.57	135
Hard Labor Creek	3596	20	0.03	0.45	230
Fishing Creek	651	10	0.03	0.11	256
Sugar Creek	566	16	0.10	0.61	560
GreenBriar Creek	538	18	0.05	0.66	260
Little Sugar Creek	368	16	0.09	0.58	675
Beaver Dam	311	11	0.04	0.21	285
Richland Creek	170	10	0.05	0.43	485
Towns Creek	113	15	0.03	0.11	498

* Most probable number by presence and absence in serial dilutions.

The volume of water from the Oconee River flowing into Lake Oconee makes it a natural focus for conservation practices. Reducing the influx of nutrients from the city of Athens should be a priority. From the confluence of the North and Middle Oconee Rivers just south of Athens the river flows through a mix of forested and agricultural land to the lake. Agricultural impacts are likely to be similar to those noted in the upper portions of the watershed away from the headwaters area and should be similar to estimates from Greenbriar Creek. Agricultural impacts are evident on Sugar and Little Sugar Creek with elevated concentrations of P, N, and fecal coliform bacteria. These two sub-watersheds merit a focused effort to reduce nutrient loading to prevent localized problems in Lake Oconee but the sum of their flows is less than 2.5% of the Oconee River flow. Sugar and Little Sugar Creeks have already attracted the attention of residents of the lake (Oconee Lake Watch, Personal Communication). Fishing and Towns Creeks are low in P and N and flow primarily from National Forest. Richland Creek is impacted by wastewater from the municipality of Greensboro. Hard Labor and Beaverdam Creeks have mixtures of activities affecting the water quality.

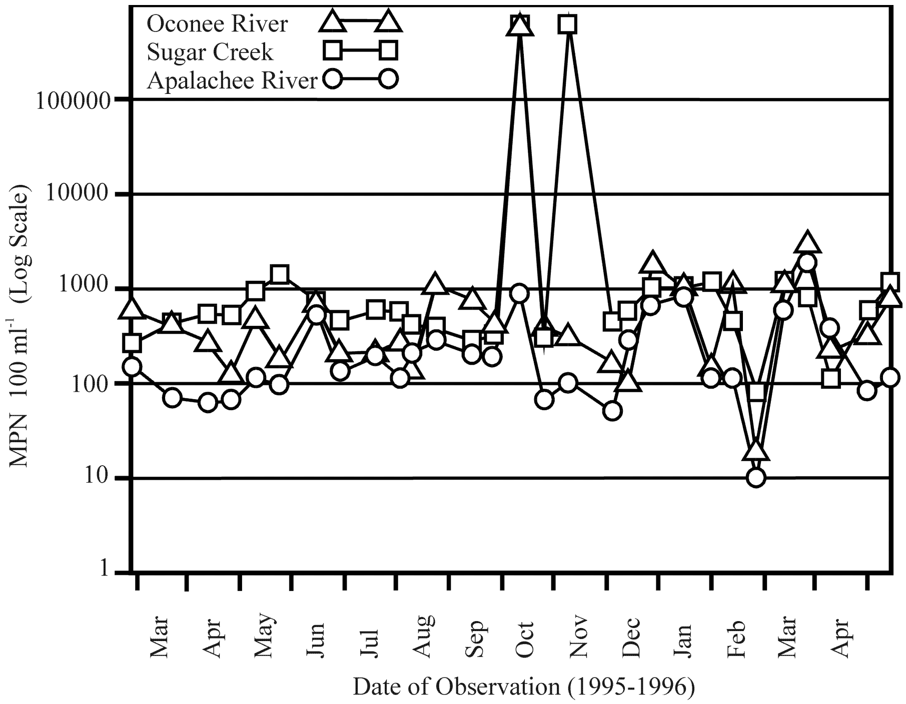

Figure 2. Most probable number (MPN) for fecal coliform bacteria 100ml^{-1} in the Oconee River (Δ), Sugar Creek ( ), and the Apalachee River (O) near Lake Oconee from a database provided by Georgia Power Company.

Fecal microbe loads can be a problem in the lake even with relatively minor water sources such as Sugar Creek. Fecal microbes can have a disproportionate impact on the ability of the lake to support its designated uses. Sugar Creek drains a relatively small watershed near the lake while the Oconee River contains runoff from most of the northern half of the watershed. Sugar Creek flow is approximately 1% of the flow of the Oconee River. However, because of the proximity of Sugar Creek to Lake Oconee it is especially prone to contribute large numbers of fecal coliform microorganisms (Figure 2).

Two notable spikes in numbers of fecal coliform bacteria occurred. The first, both the Oconee River and Sugar Creek contained more than 600,000 mpn 100 ml^{-1}. In this case the water near the northern portion of the lake would have exceeded the recommended recreational limits of 200 mpn 100 ml^{-1}. The Apalachee contained approximately 1000 mpn 100 ml^{-1} at that that time but soon returned to approximately 100 mpn 100 ml^{-1}. In the second spike, the Oconee River counts did not exceed 600 to 700 mpn 100 ml^{-1} but Sugar Creek again was found to be in excess of 600,000 mpn 100 ml^{-1}. In this case, Sugar Creek contained fecal coliform numbers three orders of magnitude greater than the Oconee River and could have presented a hazard to recreation in the lake. These effects may be important even if they are localized to a particular portion of the Lake and justify an increased focus on a smaller source of water representing only a limited portion of the watershed.

4.0 CATTLE IMPACTS ON FECAL BACTERIA IN SURFACE WATER

The presence of relatively high numbers of coliform bacteria in areas with few cattle and otherwise good quality waters such as Towns Creek (Table 2) may indicate that an alternative microbial method may be more appropriate than the fecal coliform procedure when testing for fecal contamination of water.

Two small watersheds located on the USDA-ARS J. Phil Campbell, Sr., Natural Resource Conservation Center were used to compare surface water fecal bacteria numbers in a wooded watershed without cattle to a grazed area with only the riparian zone wooded. Animals in the grazed watershed had access to the creek and the creek flowed into a pond. Both watersheds had springs. The grazed watershed presented a severe test case for fecal contamination of surface waters because no practices were used to reduce animal impact on the creek. However, animals were located in the landscape to minimize off site impact by selecting a pasture in the upper portion of the watershed. Animals had been in the grazed watershed since 1 November (1 month) before water quality sampling began weekly at both springs, both creeks, and below the pond of the grazed watershed. Samples were assayed for total coliform bacteria, E. coli, and enterococci. The assay was based on a most probable number (mpn) analysis and saturated at approximately 2500 mpn 100 ml^{-1}. Large rainfall events occurred on 24 December (99 mm) and 7 January (46 mm) and raised fecal coliform numbers in surface waters of both watersheds (Figure 3). By 8 January the assay was saturated at all samples sites except the spring in the wooded watershed. The coliform numbers in the creek of the wooded watershed were increased by the rainfall events and remained high but decreased more rapidly than the creek of the grazed watershed. The rainfall charged the pond in the grazed watershed with coliform bacteria. The creek and pond remained above the saturation level of the assay for the remainder of the study period. The high levels of coliform bacteria found in the wooded watershed could make it difficult to attribute efficacy to management practices designed to reduce offsite fecal contamination by agricultural production systems. High numbers of coliform bacteria from wildlife could account for variation in coliform levels when water quality is otherwise good (Fishing Creek vs. Towns Creek; Table 2).

The assay for enterococci indicated fecal contamination in the creek of the grazed watershed on two dates (Figure 3). The first was the result of a relatively small rainfall event on 3 December (13 mm) and the second was the result of the previously mentioned events. Rainfall combined with the access cattle had to the creek from 200 to 400 m upstream from the sample site to raise enterococci numbers. During the large rainfall events in late December and early January the creek in the wooded watershed was elevated but very low in comparison to the grazed site. The pond below the grazed watershed was very effective in removing the enterococci bacteria from the creek. The pond was less effective in removing E. coli from the grazed watershed (Figure 3). As expected, impact on the pond lagged behind the impact on the creek of the grazed watershed. The numbers of E. coli in both creeks increased as a result of the rainfall event in early January but the increase in the grazed watershed was of greater magnitude and duration. Numbers of E. coli did not respond to the small rainfall events early in the observation period but did respond to the combined 99 mm and 46 mm rainfall.

Rainfall of 13 mm on 15 January, 13 mm on 19 January, 22 mm on 22 January, and 30 mm on 27 January may have prevented a more rapid decline in the numbers of fecal coliform and E. coli bacteria at the sample sites in the grazed watershed. No conservation practices in the grazing system were used to reduce these numbers. Based upon surface hydrology, the cattle in the grazing system were strategically located in the pasture at the top of the watershed and most isolated from the surface water leaving the property. The pond located on the creek near the edge of the property was an effective means of reducing numbers of enterococci and E. coli before the water moved off the Resource Conservation Center. Property lines rarely coincide with the surface hydrology. Much of this particular grazing area does not drain to the pond. Much larger numbers of fecal bacteria would be discharged to adjoining property by locating cattle in pastures draining directly off of the property.

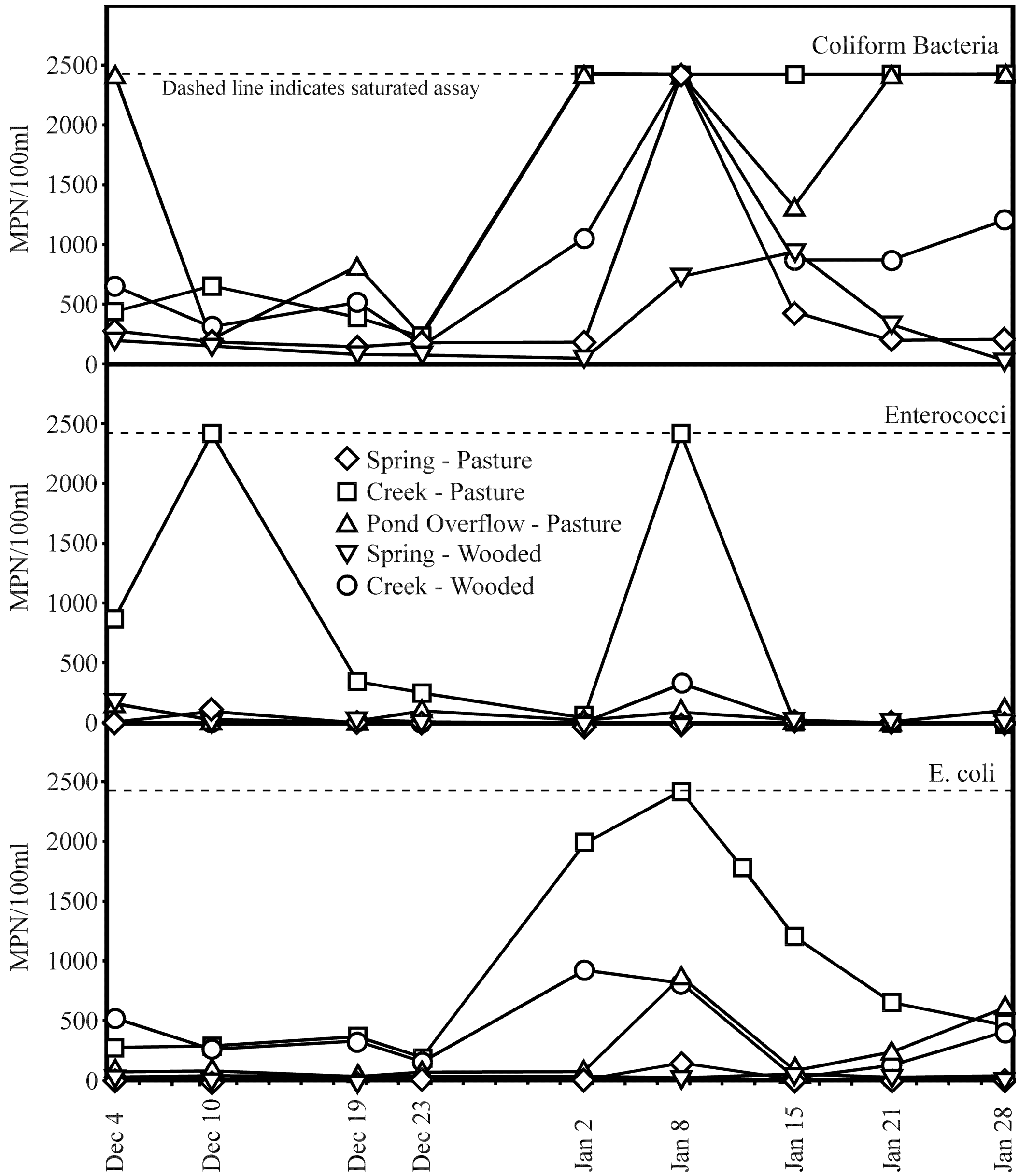

Figure 3. Most probable numbers (MPN) of fecal coliform, E. coli, and enterococci bacteria in surface water samples from a spring (◊), creek ( ), and pond overflow (Δ) in a grazed watershed and from a spring (∇) and creek (O) in a wooded watershed without domestic livestock. The dashed line indicates the level at which the microbial assay was saturated.

5.0 SUMMARY

The location of 550 poultry operations in the headwaters of the Upper Oconee Watershed has so far minimized conflicts between agricultural and urban interests. Had the poultry operations been located nearer to the intake for the Athens water supply, or closer to Lake Oconee, severe conflicts could have been expected. At this point, the watershed is functioning to separate and mitigate conflicting land uses. Agricultural production along the North Oconee may come under pressure to reduce negative impacts on the quality of the Athens water supply. A new reservoir is planned near Winder that will result in additional pressure on agricultural enterprises nearer the headwaters to reduce impacts on the Middle Oconee and Mulberry Rivers. In contrast, the residents of Lake Oconee have already noted the 30 dairies located near the lake (Oconee Lake Watch, Personal communication). Complaints and conflicts have already occurred and volunteer “Lake Watch” programs are in place. In this case, the location of the dairy enterprises prevents passive mitigation by the watershed and necessitates the use of management practices designed to prevent losses of nutrients and fecal bacteria. For agriculture in the Upper Oconee Watershed, reducing impact in this portion of the watershed must be a top priority. Dairy and beef producers have demonstrated a willingness to implement practices via the Environmental Quality Improvement Program voluntary signups. As the sophistication of the Lake Watch group increases, additional sampling protocols will be incorporated. The planned addition of sampling for phosphorus may increase conflicts with agricultural producers and will probably increase complaints against urban sources such as Athens (Oconee River) and Greensboro (Richland Creek).

A focused effort to reduce agricultural impact on water quality between Athens and Lake Oconee should also be a priority. A proactive stance by agriculture can prevent involvement in a conflict between residents of the lake and the city of Athens. Improved practices along the North Oconee to minimize impact on the Athens water supply should also be a priority. Disputes with Athens could be avoided by working with producers closest to the river to adjust animal movements within the constraints of the available property and to implement conservation practices. Eventually the poultry concentration in the headwaters must be addressed. Imports of feed and concentration of nutrients makes a sustainable solution difficult with the water demand of the growing urban population. Increased urban demand for water from the Middle Oconee may provide an increased impetus to better distribute the waste generated by the poultry operations over a wider land area and implement practices to limit loss of N, P, and fecal bacteria to the surface waters of the Oconee watershed. Efforts within the watershed should be focused to develop a planning process in which agricultural and urban interests in water quality are shared. Addressing these issues together is essential to avoid short-term counter productive conflicts and to develop a long-term vision for the watershed. “Each owner’s actions are important, not just because they affect that particular piece of land, but also because they affect neighboring land and the health of the larger ecosystems and watersheds in which they occur” (USDA, 1996).

6.0 LITERATURE

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